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EARLY HISTORY OF THE THERMOMETER.

Evolution of the Thermometer, 1592–1743. By Henry Carrington Bolton. Pp. 98. (Easton, Pa., U.S.A.: Chemical Publishing Co., 1900.) Price 1 dollar.

THIS is a most interesting little book, giving the history of the thermometer from the time of Galileo to that of Celsius and Christin.

Galileo's first instrument is thus described in a letter written by Father Castelli and dated 20th September, 1638, in which he says it was used in public lectures 35 years before. "Galileo took a glass vessel about the size of a hen's egg, fitted to a tube the width of a straw and about two spans long; he heated the glass bulb in his hands and turned the glass upside down so that the tube dipped in water held in another vessel; as soon as the ball cooled down the water rose in the tube to the height of a span above the level in the vessel; this instrument he used to investigate degrees of heat and cold."

According to Viviani, author of a "Life of Galileo," published in 1718, this instrument was invented about the time he became professor of mathematics in Padua; this was towards the end of 1592.

Sanctorius, a medical colleague of Galileo, appears to have appreciated the value of fixed points for graduation, and for this purpose he used snow and the heat of a candle; the range thus obtained he divided into degrees. The thermometer was applied by him to take the temperature of the human body; in one instrument the bulb was constructed so as to go into the patient's mouth.

Sanctorius, in his "Commentaries on Galen," speaks of the thermometer "as a most ancient instrument," and it has been suggested by Cleveland Abbe that the instrument was known before the time of Galileo and that his work consisted in the addition of a scale.

The first sealed thermometer was made some time prior to 1654 by Ferdinand II., Grand Duke of Tuscany; he filled the bulb and part of the tube with alcohol, and then sealed the tube by melting the glass tip. Ferdinand and his brother, Leopold de Medici, promoted the establishment in Florence of the Accademia del Cimento, and the accounts of their experiments, published in 1667 and translated into English by Waller in 1684, contain descriptions of various thermometers made and used by the members. One of these old thermometers was given by the Grand Duke of Tuscany to the late Prof. Babbage, and is now in the Cavendish Laboratory at Cambridge.

In England about the same time Boyle made experiments on thermometers. His "Lectures on Cold" were published in 1665 in obedience to the command of the Royal Society, "imposed on me in such a way that I thought it would less misbecome me to obey it unskilfully than not at all. Especially since from so illustrious a company (where I have the happiness not to be hated) I may, in my endeavours to obey and serve them, hope to find my failings both pardoned and made occasions of discovering the truths I aimed at."

The second discourse of these lectures contains some "New Observations about the Deficiencies of Weather Glasses, together with some considerations touching the New or Hermetical Thermometers."

Boyle felt the need of fixed points. Hooke, in his "Micrographia," describes some thermometers with stems above four feet long, in which the range between summer and winter was nearly the length of the stem. To graduate the stems he placed zero at the point where the liquid stood when the bulb was in freezing distilled water; thus to him belongs the credit of taking the temperature of the freezing point of water as the lower fixed point.

There appears to be considerable doubt as to who first employed mercury as the thermometric liquid; the Accademia del Cimento used such an instrument in 1657, and they were known in Paris in 1659. Fahrenheit, however, appears to have been the first to construct, in 1714, mercury thermometers having trustworthy scales.

The use of the boiling point of water as the upper fixed point was suggested by Carlo Renaldini in 1694, who published, at the age of eighty years, a work on natural philosophy.

Sir Isaac Newton, in his "Scala Graduorum," published in the *Phil. Trans.* in 1701, adopts linseed oil as the thermometric liquid. He took as the fixed points the melting point of ice and the temperature of the human body, calling the one 0° and the other 12°. On this scale he gives as the boiling point of water 34°, and as the melting point of lead 96°. Newton did not adopt the boiling point of water as a fixed point.

After an interesting reference to Amontons and others who worked at thermometry in the latter part of the seventeenth century, Mr. Bolton describes the labours of Fahrenheit, who was born in 1686. His work began in 1706. His skill as a glass worker was very great and enabled him to carry out many designs. In his own account of the instrument he says: "The scale of the thermometers used for meteorological observations begins below with 0° and ends with 96°. The division of the scale depends upon three fixed points, which are obtained in the following manner. The first point below at the beginning of the scale was found by a mixture of ice water and sal ammoniac or also sea salt; when a thermometer is put in such a mixture the liquid falls until it reaches a point designated as zero .... The second point is obtained when water and ice are mixed without the salts named; when a thermometer is put into this mixture the liquid stands at 32°, and this I call the commencement of freezing .... The third point is at 96°. The alcohol"—it is expressly stated earlier that the thermometers were of two kinds, the one containing alcohol, the other mercury—"expands to this height when the thermometer is placed in the mouth or in the armpit of a healthy man and held there until it acquires the temperature of the body."

Above this temperature the scale was merely lengthened by dividing the tube into equal spaces; one of the divisions marked 212° on a certain thermometer was observed to coincide with the boiling point of water, thus the division of the fundamental interval between the freezing point and boiling point into 180 parts was accidental. If we take these two temperatures as our points of departure, marking them as 32° and 212°, the normal temperature of the human body is 98°·4, not 96°

as on Fahrenheit's original scale, so that the scale now known by his name differs slightly from that originally defined by him. Two of his original instruments are in the Physical Laboratory at Leyden; the freezing points as now given by them are at 34°·2 and 34°·1 respectively; both of these are mercury thermometers.

After Fahrenheit's time came various imitators, each with his own special scale; for an account of them we must refer the reader to Mr. Bolton's pages. Among them the scales of Réaumur and of Celsius alone survive, though, as Mr. Bolton points out, Celsius proposed to call the boiling point of water 0° and its freezing point 100°; the change to the present centigrade scale was made independently in 1743 by Christin, of Lyons, and seven years later by Strömer, a colleague of Celsius at Upsala.

Réaumur's choice of 80° for the temperature of steam was made as a result of his experiments on the expansion of alcohol. He found that alcohol, diluted with one-fifth water, expanded in volume from 1000 to 1080 when raised from the freezing point to the boiling point.

Mr. Bolton is to be congratulated on his work. He has made it most interesting, and it deserves many readers; it suggests the hope that some one may take up similarly the history of other physical instruments and write about them in as bright and capable a manner.

THE OXFORD TEXT-BOOK OF ZOOLOGY.

A Treatise on Zoology. Edited by E. Ray Lankester Part II. *The Porifera and Coelentera.* By E. A. Minchin, G. H. Fowler and G. C. Bourne. With an introduction by E. Ray Lankester. Pp. x + 405. (London: Adam and Charles Black, 1900.)

THE second part of the "Treatise on Zoology," now appearing under the editorship of Prof. Ray Lankester, contains six chapters, the work of four different authors, graduates of the University of Oxford. An introductory chapter by the editor, on the Enterocœla and Cœlomocœla, deals with the main divisions of the Metazoa; Prof. E. A. Minchin writes on the Sponges; Dr. G. H. Fowler on Hydromedusæ and Scyphomedusæ; and Mr. G. C. Bourne on the Anthozoa and Ctenophora. The high character of the whole work, of which the volume previously published (Part III. Echinoderma) gave promise, is fully established by that now before us, and it can scarcely be doubted that this treatise will, for some time to come, be regarded as the standard English text-book for advanced students of zoology.

The classification of the Metazoa adopted by Prof. Lankester in the introductory chapter is based upon the work of the most recent writers on animal morphology, and differs in several ways from that previously adopted in the text-books. The whole animal kingdom having first been divided into two grades, the Protozoa and the Metazoa, the grade Metazoa is considered as giving rise to two branches, the Parazoa, or Sponges, and the Enterozoa, the latter name being a term previously introduced by Prof. Lankester as a substitute for Haeckel's term Metazoa, but which he now proposes to restrict to the second great division of the Metazoa. The view thus adopted of the position of Sponges in the animal kingdom is that advocated by Minchin in the present work (see p. 158); but, as that author points out, it is one which is by no means accepted, at the present time, by other leading authorities on the morphology of the Porifera.

After this main division of the Metazoa, Prof. Lankester proceeds to divide the Enterozoa into two branches, the Enterocœla, or those in which the sole cavity is the enteron, and the Cœlomocœla, those in which the cœlom is present as an independent second cavity. It is certainly open to doubt whether any advantage is gained by the introduction, in a work of this character, of these new terms to replace the already so widely used Cœlentera (or Cœlenterata) and Cœlomata. Indeed, Prof. Lankester himself appears to regard his new nomenclature as tentatively put forward for the consideration of his fellow morphologists, for it is not even adopted in the present volume. The title-page bears the name Cœlentera, and this is the term used both by Mr. Bourne and Dr. Fowler in their sections of the work, the latter writer making use also of the form Cœlenterata (p. 60), to which the editor of the treatise takes exception.

The remaining portion of the introductory chapter gives, in a clear and interesting manner, an account of the author's views with regard to the cœlom and its relations to the other cavities of the body in the different phyla of the Cœlomata (Cœlomocœla), together with a detailed history of the progress of our knowledge of that organ. The discussion of this subject is noteworthy on account of the particularly clear statement of the author's theory of the body-cavity relations found in the Mollusca and Arthropoda. According to this theory, now termed the theory of Phlebœdesis, the true cœlom is present in these groups in a reduced form, whilst the blood-holding spaces (hæmocœl) are in reality swollen blood-vessels. In support of this view, Benham's work on *Magelona* (*Quart. Journ. Micr. Sci.*, xxxix. 1896) is brought forward. The concluding part of the chapter is of interest from the great importance attached to the recent work of Meyer and of Goodrich on the nephridia and cœlomoducts of the marine Chætopoda, the views of these authors being entirely adopted, notwithstanding the fact that they revolutionise the prevailing ideas on the subject, ideas which owe their origin very largely to Prof. Lankester himself.

Prof. Minchin's section on the Sponges, we have little hesitation in saying, contains the most successful account of an animal group which has yet appeared in this treatise. It is in many ways a model of what such a general account should be, and is certainly the most satisfactory summary of our knowledge of the Porifera which at present exists in any language. It is by no means merely a compilation and discussion of facts already put on record by other authors. Much new matter is here recorded for the first time—notably the account of the development of *Clathrina blanca*—and a large part of the descriptive portions of the chapter is the direct outcome of the author's own observation and experience. Prof. Minchin's work as a histologist, which has shown him to be an expert in the most recent and delicate methods of technique, is well known, but the present article proves him to be at the same time a painstaking and observant outdoor naturalist. That a sponge is a living organism and that each species is specially adapted